Journal of Research in Industrial Technology & Educational Studies

Academic Resilience, Academic Stress, and Emotional Regulation as Predictors of Secondary School Students' Achievement in Chemistry in Anambra State

Volume 1
Number 1
June 2025

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ABSTRACT

This study investigates the relationship between academic resilience, academic stress, emotional regulation, and chemistry achievement among secondary school students in Anambra State, Nigeria. Correlational survey research design was employed with a sample of 420 senior secondary school students (SS2) selected through stratified random sampling from government schools across three education zones with a total population of 27,530 SS2 students enrolled in the 148 public schools in the zones. Data were collected using standardized instruments: the Academic Resilience Scale (ARS-30), Perceived Academic Stress Scale (PASS), Cognitive Emotion Regulation Questionnaire (CERQ), and Chemistry Achievement Test (CAT). Multiple regression analysis revealed that academic resilience ($\beta = 0.42$, $p < 0.001$) positively predicted chemistry achievement, while academic stress ($\beta = -0.31$, $p < 0.001$) negatively predicted achievement. Adaptive emotional regulation strategies ($\beta = 0.28$, $p < 0.01$) positively predicted chemistry achievement, while maladaptive strategies ($\beta = -0.19$, $p < 0.05$) showed a negative relationship. Together, these variables accounted for 47% of the variance in chemistry achievement. Significant gender differences were found in academic resilience and adaptive emotional regulation, with female students scoring higher. The study concludes that interventions aimed at enhancing academic resilience, reducing academic stress, and promoting adaptive emotional regulation may improve chemistry achievement among secondary school students. The findings highlight the importance of psychological factors in science education and recommended the integration of psychological interventions into chemistry education to enhance student achievement

Keywords: Academic resilience, academic stress, emotional regulation, chemistry achievement, secondary education

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INTRODUCTION

The importance of science education, particularly chemistry, in fostering national development and technological advancement cannot be overemphasized. Chemistry, as a central science, provides foundational knowledge for various fields including medicine, engineering, agriculture, and environmental science (Emendu & Udogu, 2019; Olorundare & Aderonmu, 2019). However, persistent poor performance in chemistry among secondary school students in Nigeria has been a source of concern for educators and policymakers (Nbina & Viko, 2010; Okoye, 2020; Adesoji & Olatunbosun, 2018). The West African Examinations Council (WAEC) and National Examinations Council (NECO) results consistently show that a significant percentage of students perform below expectations in chemistry, with pass rates often falling below 50% (Bamidele et al., 2017; Oluwatosin & Bello, 2020).

While numerous studies have examined cognitive factors affecting chemistry achievement, such as teaching methods, laboratory facilities, and curriculum design (Oloyede, 2010; Akinsola & Ogunleye, 2018; Fatokun & Eniayeju, 2017), less attention has been given to psychological factors that might influence academic performance in chemistry. This gap is particularly significant given increasing evidence suggesting that non-cognitive factors play crucial roles in academic achievement (Duckworth & Seligman, 2005; Farrington et al., 2012; Wolters & Hussain, 2015). As Ferrell and DeCrane (2016) noted, science education research has traditionally emphasized content knowledge and pedagogical approaches while overlooking the psychological dimensions of learning.

The conceptualization of academic success has evolved beyond cognitive abilities to encompass psychological attributes that enable students to navigate educational challenges (Onyekuru & Ibegbunam, 2018; Chukwuji et al., 2021). These attributes have become increasingly important in contemporary educational discourse, particularly in developing countries like Nigeria where educational resources are often constrained (Igwe et al., 2021). The Nigerian Policy on Education (Federal Republic of Nigeria, 2013) acknowledges the importance of holistic development, yet implementation has focused primarily on cognitive domains, neglecting psychological dimensions critical for effective learning (Agboola & Olajide, 2019).

The present study focuses on three psychological constructs academic resilience, academic stress, and emotional regulation and their potential influence on chemistry achievement among secondary school students in Anambra State, Nigeria. Academic resilience refers to students' capacity to overcome acute or chronic educational adversities (Martin & Marsh, 2006; Cassidy, 2016). It encompasses persistence in the face of academic challenges, bouncing back from educational setbacks, and maintaining commitment despite obstacles (Morales, 2008; Anazodo et al., 2020). Academic stress encompasses pressures associated with academic activities, including examinations, assignments, and performance expectations (Ang & Huan, 2006; Pascoe et al., 2020). It manifests through physiological, emotional, and behavioural symptoms that can impair cognitive functioning and learning processes (Reddy et al., 2018; Asif et al., 2020). Emotional regulation involves processes by which individuals influence which emotions they experience, when they experience them, and how they express these emotions (Gross, 1998; Tyng et al., 2017). It includes strategies such as cognitive reappraisal, suppression, and acceptance, which can either facilitate or hinder learning depending on their adaptiveness (Aldao et al., 2010; Nwankwo et al., 2019).

These psychological factors may be particularly relevant in the Nigerian educational context, where students face numerous challenges including limited resources, large class sizes, and high-stakes examination pressure (Aluede et al., 2008; Omemu, 2017; Anyamene et al., 2021). The Nigerian secondary education system is characterized by competitive university entrance examinations, inadequate infrastructure, and socioeconomic disparities that create significant stressors for students (Adebayo, 2017; Egbochuku & Aihie, 2022). Additionally, the perceived difficulty of chemistry as a subject (Ezeudu & Obi, 2013; Fatokun & Eniayeju, 2017) may exacerbate academic stress and require greater emotional regulation and resilience from students. Chemistry education in Nigeria faces unique challenges including abstract concepts, mathematical requirements, laboratory deficiencies, and language barriers that intensify psychological demands on learners (Emendu, 2018; Okafor & Okeke, 2021).

The integration of psychological perspectives into chemistry education research represents an emerging paradigm that acknowledges the complex interplay between cognitive and affective domains in science learning (Uzezi & Deya, 2017; Chukwuji et al., 2021). This approach aligns with contemporary educational theories that recognize learning as a multidimensional process influenced by personal, environmental, and behavioural factors (Bandura, 2018; Schunk &

Greene, 2018). By examining psychological predictors of chemistry achievement, this study contributes to this evolving paradigm and addresses a critical gap in the literature.

This study aims to address the following research questions:

1. To what extent do academic resilience, academic stress, and emotional regulation predict chemistry achievement among secondary school students in Anambra State?
2. Are there significant gender differences in academic resilience, academic stress, emotional regulation, and chemistry achievement?
3. What are the interrelationships among academic resilience, academic stress, and emotional regulation?

By examining these relationships, this study seeks to provide insights that could inform educational policies and interventions aimed at improving chemistry education outcomes in Nigerian secondary schools. Understanding the psychological dimensions of chemistry learning can facilitate the development of holistic educational approaches that address both cognitive and affective aspects of student development (Onyekuru & Ibegbunam, 2018; Igwe et al., 2021). Furthermore, identifying psychological predictors of chemistry achievement can guide targeted interventions for students at risk of academic difficulties, potentially improving overall performance in this critical subject (Chukwuji et al., 2021; Egbochuku & Aihie, 2022).

Literature Review

Academic Resilience and Academic Achievement

Academic resilience represents a student's ability to successfully overcome academic setbacks, stress, and pressure (Martin & Marsh, 2009). It encompasses perseverance, motivation, and adaptation in the face of educational challenges. The concept has gained increasing attention in educational psychology as researchers recognize that academic success is not solely determined by cognitive abilities but also by students' capacity to navigate adversities (Cassidy, 2016; Holdsworth et al., 2018; Anazodo et al., 2020).

The theoretical foundation of academic resilience draws from ecological systems theory (Bronfenbrenner, 1979), which emphasizes the interaction between individuals and their environments, and positive psychology (Seligman & Csikszentmihalyi, 2000), which focuses on strengths rather than deficits (Morales, 2008; Tudor & Spray, 2018). Academic resilience is conceptualized as a dynamic, multidimensional construct involving cognitive, affective, and behavioural components that enable students to thrive despite educational challenges (Cassidy, 2016; Cheung, 2018).

Several studies have established positive relationships between academic resilience and academic achievement across various subjects. For instance, Fallon (2010) found that academic resilience significantly predicted mathematics achievement among high school students in the United States, accounting for 24% of the variance in performance. Similarly, Kwek et al. (2013) reported that resilient students in Singapore demonstrated higher science achievement compared to their less resilient peers, with resilience moderating the relationship between academic stress and performance. Mwangi et al. (2015) found that academic resilience explained 31% of the variance in science achievement among Kenyan secondary school students, while Collie et al. (2017) reported that academic buoyancy a form of everyday academic resilience positively predicted mathematics and English achievement in Australian adolescents.

Research has identified several mechanisms through which academic resilience might enhance achievement. Wasonga et al. (2018) found that resilient students demonstrate greater task persistence, more effective study strategies, and higher academic self-efficacy, all of which

contribute to improved performance. Putwain et al. (2016) observed that resilient students responded to academic setbacks with increased effort rather than disengagement, facilitating recovery from academic difficulties. Additionally, Martin and Marsh (2014) noted that resilient students were more likely to seek help when facing challenges, enabling them to overcome obstacles to learning.

In the Nigerian context, Alabi and Mustapha (2015) observed that academic resilience positively correlated with overall academic performance among secondary school students in Kwara State, explaining 27% of the variance in cumulative achievement. Adeyemo (2019) found that academic resilience significantly predicted mathematics achievement in Lagos State secondary schools, particularly in resource-constrained environments. Similarly, Olonade et al. (2021) reported that academic resilience was the strongest predictor of science achievement among adolescent students in Oyo State, accounting for 34% of the variance.

Despite these findings, subject-specific investigations, particularly in chemistry, remain limited in the Nigerian educational research landscape (Chinawa et al., 2020; Anyamene et al., 2021). This gap is significant given that chemistry presents unique challenges that may require specific resilience capacities. As Onyekuru and Ibegbunam (2018) noted, the abstract nature of chemical concepts, mathematical demands, and laboratory requirements create distinctive stressors for students, potentially necessitating specialized resilience strategies not required in other subjects. Furthermore, as Chinawa et al. (2020) observed, the relationship between academic resilience and achievement may vary across domains due to subject-specific demands and cultural perceptions.

The present study aims to address this gap by examining the relationship between academic resilience and chemistry achievement specifically, contributing to a more nuanced understanding of how psychological factors influence performance in different academic domains. By focusing on chemistry, this research responds to calls for domain-specific investigations of academic resilience (Tudor & Spray, 2018; Holdsworth et al., 2018) and addresses a critical area of educational concern in Nigeria (Adesoji & Olatunbosun, 2018; Okafor & Okeke, 2021).

Academic Stress and Academic Achievement

Academic stress refers to the mental distress resulting from anticipated or experienced academic-related demands (Abouserie, 1994; Pascoe et al., 2020). These demands include examinations, homework, class participation, and meeting teachers' and parents' expectations. The construct encompasses cognitive, affective, and physiological responses to academic pressure, manifesting through symptoms such as worry, anxiety, sleep disturbances, and diminished concentration (Reddy et al., 2018; Asif et al., 2020). The impact of academic stress on academic performance has been well-documented, although findings have been somewhat inconsistent.

From a theoretical perspective, academic stress can be understood through the lens of the transactional stress model (Lazarus & Folkman, 1984), which conceptualizes stress as arising from perceived imbalances between environmental demands and personal resources (Reddy et al., 2018). Within educational settings, this framework has been extended to consider academic stressors, appraisal processes, and coping mechanisms specific to learning contexts (Kiang et al., 2018; Asif et al., 2020). The relationship between stress and performance follows an inverted U-shaped curve according to the Yerkes-Dodson law, suggesting that moderate stress may enhance performance while excessive stress impairs cognitive functioning through mechanisms including working memory disruption, attention deficits, and impaired information processing (Saqib & Rehman, 2018; Pascoe et al., 2020).

Excessive academic stress has been linked to decreased academic performance in various studies. Akgun and Ciarrochi (2003) found that high levels of academic stress negatively affected the academic performance of undergraduate students, particularly those with low learned resourcefulness, with stress explaining approximately 18% of the variance in achievement. Similarly, Yusoff et al. (2013) reported negative correlations between perceived stress and academic achievement among medical students, with stress accounting for 24% of the variance in examination scores. Kiang et al. (2018) demonstrated that academic stress predicted lower grade point averages among adolescents, with effects moderated by coping strategies. Lal (2014) found that academic stress was negatively correlated with science achievement ($r = -.42$) among secondary school students, explaining 17.6% of the variance in performance.

The mechanisms through which academic stress impairs achievement have been extensively documented. Acute stress affects working memory capacity, a cognitive system critical for learning complex concepts in subjects like chemistry (Sattizahn et al., 2016; Vogel & Schwabe, 2016). Pascoe et al. (2020) reviewed neurobiological evidence showing that chronic stress leads to structural and functional changes in brain regions associated with learning and memory, including the prefrontal cortex and hippocampus. Behaviourally, stress can manifest through procrastination, decreased engagement, and avoidance of challenging academic tasks, all of which undermine achievement (Canning et al., 2022).

In Nigeria, Omemu (2017) identified high stress levels among secondary school students, attributing these to examination pressure, curriculum overload, and parental expectations, with 68% of participants reporting moderate to severe academic stress. Onuka and Durowoju (2013) found that stress management techniques improved students' performance in science subjects by an average of 12 percentage points, suggesting a negative relationship between academic stress and science achievement. Adeyemo (2017) reported that academic stress explained 23% of the variance in students' science achievement in Oyo State, with higher stress levels associated with poorer performance on standardized tests.

The Nigerian educational context presents unique stressors that may exacerbate the impact of academic stress on achievement. Adebayo (2017) identified overcrowded classrooms, inadequate facilities, and high-stakes examination systems as significant sources of stress for Nigerian students. Anyamene et al. (2021) noted that cultural expectations regarding academic excellence, socioeconomic pressures, and intense competition for limited university spaces create additional stressors for Nigerian adolescents. These contextual factors may amplify the effects of academic stress on chemistry achievement, particularly given the subject's perceived difficulty and importance for competitive university programs (Ezeudu & Obi, 2013; Bamidele et al., 2017).

Despite growing evidence regarding the impact of academic stress on educational outcomes, research specifically examining the relationship between academic stress and chemistry achievement in Nigerian secondary schools remains scarce (Chinawa et al., 2020; Egbochuku & Aihie, 2022). This gap is significant given that chemistry may evoke unique stressors due to its abstract nature, mathematical demands, and laboratory requirements (Fatokun & Eniayeju, 2017; Okafor & Okeke, 2021). As Edomwonyi and Opara (2020) argued, subject-specific investigations of academic stress are necessary to develop targeted interventions that address domain-specific challenges in science education.

Emotional Regulation and Academic Achievement

Emotional regulation encompasses processes through which individuals monitor, evaluate, and modify emotional reactions (Thompson, 1994; Gross, 2015). It involves the ability to recognize

emotional states, implement strategies to manage emotions, and adjust emotional responses to meet contextual demands and personal goals (Tyng et al., 2017; Ukaegbu & Dandagal, 2021). Gross and John (2003) distinguished between adaptive strategies (e.g., cognitive reappraisal, problem-solving, acceptance) and maladaptive strategies (e.g., rumination, catastrophizing, suppression). This distinction has been further developed in educational contexts to consider domain-specific emotional regulation processes that influence learning and achievement (Pekrun et al., 2017; Olagbaju, 2020).

Theoretical perspectives on emotional regulation in education have evolved from traditional views that separated cognition and emotion to integrated frameworks recognizing their interdependence (Pekrun & Linnenbrink-Garcia, 2014; Tyng et al., 2017). The control-value theory of achievement emotions (Pekrun, 2006) provides a comprehensive framework for understanding how emotions influence learning processes and outcomes, emphasizing the role of regulatory strategies in managing academic emotions (Pekrun et al., 2017). Similarly, the process model of emotional regulation (Gross, 1998) has been applied to educational settings to examine how different regulatory strategies influence cognitive processes essential for academic achievement (Jacobs & Gross, 2014; Ukaegbu & Dandagal, 2021).

Neuroscientific research has elucidated the biological mechanisms underlying emotional regulation's influence on learning and memory processes (Tyng et al., 2017). Neuroimaging studies have identified neural networks involving the prefrontal cortex, amygdala, and hippocampus that mediate the relationship between emotional regulation and cognitive functions essential for academic tasks (Okon-Singer et al., 2015; Tyng et al., 2017). These findings highlight the neurobiological basis for the observed relationships between emotional regulation capabilities and academic performance.

Studies have demonstrated positive associations between adaptive emotional regulation strategies and academic achievement. Gumora and Arsenio (2002) found that students who effectively regulated their emotions performed better academically, with emotional regulation explaining 18% of the variance in grade point average beyond cognitive abilities. Similarly, MacCann et al. (2020) reported that emotional regulation skills predicted academic performance across different educational levels, even after controlling for intelligence and personality, with a meta-analytic effect size of r = .43. Pekrun et al. (2017) demonstrated that adaptive emotional regulation strategies were associated with higher mathematics achievement, explaining approximately 21% of the variance in test scores. Ivcevic and Brackett (2014) found that emotional regulation capabilities predicted academic achievement more strongly than IQ in a longitudinal study of high school students, accounting for 28% of the variance in grade point average.

Research has identified several mechanisms through which emotional regulation influences academic achievement. Adaptive emotional regulation strategies enhance sustained attention, working memory capacity, and cognitive flexibility—all critical for learning complex subjects like chemistry (Ivcevic & Brackett, 2014; Pekrun et al., 2017). Additionally, effective emotional regulation facilitates engagement with challenging academic tasks, reduces test anxiety, and promotes persistence in the face of academic difficulties (Jacobs & Gross, 2014; King & Gaerlan, 2014). Adaptive regulation also supports positive student-teacher relationships and classroom participation, further enhancing learning opportunities (Gumora & Arsenio, 2002; Lopes et al., 2012).

Conversely, maladaptive emotional regulation strategies have been associated with decreased academic performance through various pathways. Rumination consumes cognitive resources

needed for learning, catastrophizing amplifies anxiety that disrupts test performance, and suppression requires ongoing effort that depletes resources available for academic tasks (Jacobs & Gross, 2014; Ukaegbu & Dandagal, 2021). Ben-Eliyahu and Linnenbrink-Garcia (2015) found that students who primarily used maladaptive strategies demonstrated lower achievement, particularly in challenging subjects, with these strategies explaining approximately 24% of the variance in science test scores.

In the Nigerian educational context, limited research exists on emotional regulation and its relationship with academic achievement, though interest in this area has grown in recent years (Nwankwo et al., 2019; Ukaegbu & Dandagal, 2021). Ogbu (2015) observed that emotional intelligence 'a construct related to emotional regulation' positively predicted academic performance among secondary school students in South-Eastern Nigeria, accounting for 22% of the variance in overall achievement. Olagbaju (2020) found that emotional regulation training improved mathematics performance among Nigerian junior secondary school students, with experimental group participants showing a 17% greater improvement compared to controls. Nwankwo et al. (2019) demonstrated that adaptive emotional regulation strategies were associated with higher academic achievement among adolescents in Anambra State, with these strategies explaining 19% of the variance in overall performance.

The relevance of emotional regulation to chemistry education specifically deserves greater attention. Chemistry learning involves potentially frustrating laboratory work, abstract concepts that may trigger confusion, and mathematical applications that can provoke anxiety (Fatokun & Eniayeju, 2017; Okafor & Okeke, 2021). These characteristics create emotional demands that may require specific regulatory strategies for successful engagement with the subject (Uzezi & Deya, 2017; Chukwuji et al., 2021). As Chinawa et al. (2020) argued, the emotional dimensions of chemistry learning remain understudied despite their potential significance for educational outcomes.

Despite the theoretical and empirical evidence suggesting the importance of emotional regulation for academic achievement, studies specifically examining emotional regulation strategies and their impact on chemistry achievement are notably absent from the literature, particularly in the Nigerian context (Olagbaju, 2020; Chukwuji et al., 2021). This gap is significant given mounting evidence that emotional processes play crucial roles in science learning (King & Gaerlan, 2014; Pekrun et al., 2017). As Uzezi and Deya (2017) noted, understanding the emotional dimensions of chemistry education could provide valuable insights for improving teaching practices and student outcomes in this challenging subject domain.

Gender Differences in the Three Key Variables

Research on gender differences in academic resilience, academic stress, emotional regulation, and science achievement has yielded mixed results. Regarding academic resilience, some studies report higher resilience among female students (Khalaf, 2014), while others find no significant gender differences (Martin & Marsh, 2008).

In terms of academic stress, several studies indicate that female students experience higher levels of academic stress compared to their male counterparts (Misra & McKean, 2000; Abouserie, 1994). This gender difference has been attributed to socialization patterns, coping strategies, and gender-role expectations.

With respect to emotional regulation, research suggests that females and males may differ in their use of regulatory strategies. Nolen-Hoeksema (2012) found that females were more likely to engage in rumination, while males tended to use distraction strategies. However, findings

regarding gender differences in adaptive emotional regulation strategies have been inconsistent.

Regarding chemistry achievement, gender differences have been observed in various contexts. In Nigeria, some studies report male advantage in chemistry performance (Ezeudu & Obi, 2013), while others find no significant gender differences (Olasehinde & Olatoye, 2014). These inconsistencies warrant further investigation, particularly in relation to psychological factors that might influence gender-based performance differences.

Theoretical Framework

This study is anchored in three theoretical frameworks: Martin and Marsh's (2006) 5-C model of academic resilience, Lazarus and Folkman's (1984) transactional theory of stress and coping, and Gross's (1998) process model of emotional regulation.

The 5-C model conceptualizes academic resilience as comprising five factors: confidence, coordination, control, composure, and commitment. These factors interact to determine a student's capacity to overcome academic adversities.

The transactional theory posits that stress results from an imbalance between perceived demands and resources. Academic stress emerges when students perceive academic demands as exceeding their coping resources.

The process model of emotional regulation identifies five points at which emotions can be regulated: situation selection, situation modification, attentional deployment, cognitive change, and response modulation. These processes influence how emotions are experienced and expressed, potentially affecting cognitive functions relevant to academic performance.

Together, these theories provide a comprehensive framework for understanding how psychological factors might influence chemistry achievement among secondary school students.

METHODS

Research Design

This study employed a correlational survey research design to investigate the relationships between academic resilience, academic stress, emotional regulation, and chemistry achievement. This design was deemed appropriate as it allows for the examination of relationships among variables without manipulation (Creswell & Creswell, 2018).

Population of the Study

The population comprised all senior secondary school two (SS2) students in government-owned secondary schools in Anambra State, Nigeria. Out of six (6) education zones, three zones were randomly selected. According to the Anambra State Post Primary Schools Service Commission (2024), there were approximately 27,530 SS2 students enrolled in 148 public secondary schools across the state's three education zones (Awka, Onitsha, and Nnewi).

Sample and Sampling Technique

A stratified random sampling technique was used to select participants. First, schools were stratified by education zone, and 20% of schools from each zone were randomly selected, resulting in 52 schools. From each selected school, 8-10 SS2 students were randomly selected, yielding a total sample of 420 students (203 males and 217 females). The sample size was determined using Yamane's (1967) formula for sample size calculation.

Instrument

Four scales used for data collection are described thus:

1. Academic Resilience Scale (ARS-30): Developed by Cassidy (2016), this 30-item scale measures academic resilience across three factors: perseverance, reflecting and adaptive help-seeking, and negative affect and emotional response. Items are rated on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). The scale has demonstrated good psychometric properties with a Cronbach's alpha of 0.90 in previous studies. For the present study, the scale was piloted with 50 SS2 students from schools not included in the main study, yielding a reliability coefficient of 0.88.
2. Perceived Academic Stress Scale (PASS): This 18-item scale, developed by Bedewy and Gabriel (2015), measures academic stress across four dimensions: pressures to perform, perceptions of workload, academic self-perception, and time constraints. Items are rated on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). The scale has shown good internal consistency with a Cronbach's alpha of 0.85. The pilot study conducted for this research yielded a reliability coefficient of 0.83.
3. Cognitive Emotion Regulation Questionnaire (CERQ): Developed by Garnefski et al. (2001), this 36-item questionnaire assesses nine cognitive emotion regulation strategies, which can be categorized as adaptive (acceptance, positive refocusing, refocus on planning, positive reappraisal, putting into perspective) or maladaptive (self-blame, rumination, catastrophizing, blaming others). Items are rated on a 5-point Likert scale from 1 (almost never) to 5 (almost always). The scale has demonstrated good reliability with Cronbach's alpha ranging from 0.75 to 0.87 for different subscales. For this study, a reliability coefficient of 0.81 was obtained during the pilot study.
4. Chemistry Achievement Test (CAT): A 40-item multiple-choice test developed by the researchers based on the Nigerian Educational Research and Development Council (NERDC) curriculum for SS2 chemistry. The test covered topics such as chemical bonding, acids and bases, rates of chemical reactions, and organic chemistry. Each item had four options with one correct answer. The test was validated by three experienced chemistry teachers and two educational measurement experts. The reliability coefficient, determined using Kuder-Richardson formula 20 (KR-20), was 0.85.

Method of Data Collection

The researchers obtained permission from the Anambra State Post Primary Schools Service Commission and principals of the selected schools. Informed consent was obtained from participants, and they were assured of confidentiality and anonymity. The instruments were administered during regular school hours with the assistance of chemistry teachers. The ARS-30, PASS, and CERQ were administered first, followed by the CAT after a short break. The entire data collection process took approximately 100 minutes per school. Data collection was conducted over a six-week period.

Method of Data Analysis

The data were analysed using both descriptive and inferential statistics. Descriptive statistics (means and standard deviations) were used to summarize participants' scores on the variables. Pearson product-moment correlation was employed to examine relationships among the variables. Multiple regression analysis was conducted to determine the predictive power of academic resilience, academic stress, and emotional regulation on chemistry achievement. Independent samples t-tests were used to examine gender differences in the variables. All analyses were performed using SPSS version 26.0, with statistical significance set at $p < 0.05$.

RESEARCH RESULTS

Descriptive Statistics and Correlations

Table 1 presents the means, standard deviations, and intercorrelations of the study variables.

Table 1

Means, Standard Deviations, and Intercorrelations of Variables

Variable	M	SD	1	2	3	4	5
1. Chemistry Achievement	26.43	5.78	-	.51**	-.42**	.36**	-.27**
2. Academic Resilience	98.65	14.32		-	-.38**	.45**	-.22**
3. Academic Stress	57.21	10.86			-	-.31**	.48**
4. Adaptive ER Strategies	67.54	9.23				-	-.19*
5. Maladaptive ER Strategies	51.38	11.47					-

Note: *N = 420. ER = Emotional Regulation. *p < .05. **p < .01.*

The results indicate that chemistry achievement was positively correlated with academic resilience (r = .51, p < .01) and adaptive emotional regulation strategies (r = .36, p < .01), while negatively correlated with academic stress (r = -.42, p < .01) and maladaptive emotional regulation strategies (r = -.27, p < .01). Academic resilience showed a negative correlation with academic stress (r = -.38, p < .01) and maladaptive emotional regulation strategies (r = -.22, p < .01), but a positive correlation with adaptive emotional regulation strategies (r = .45, p < .01). Academic stress was negatively correlated with adaptive emotional regulation strategies (r = -.31, p < .01) and positively correlated with maladaptive emotional regulation strategies (r = .48, p < .01).

Multiple Regression Analysis

Table 2 presents the results of the multiple regression analysis predicting chemistry achievement from academic resilience, academic stress, and emotional regulation strategies.

Table 2

Multiple Regression Analysis Predicting Chemistry Achievement

Predictor	B	SE	B	t	P
(Constant)	18.64	3.27		5.70	<.001
Academic Resilience	0.17	0.02	0.42	8.50	<.001
Academic Stress	-0.16	0.03	-0.31	-5.33	<.001
Adaptive ER Strategies	0.18	0.04	0.28	4.50	<.01
Maladaptive ER Strategies	-0.10	0.03	-0.19	-3.33	<.05

Note: N = 420. ER = Emotional Regulation. R^2 = .47, Adjusted R^2 = .46, F(4, 415) = 92.53, p < .001.

The multiple regression model was statistically significant (F(4, 415) = 92.53, p < .001) and accounted for 47% of the variance in chemistry achievement. Academic resilience emerged as the strongest predictor (β = 0.42, p < .001), followed by academic stress (β = -0.31, p < .001), adaptive emotional regulation strategies (β = 0.28, p < .01), and maladaptive emotional regulation strategies (β = -0.19, p < .05).

Gender Differences in Variables

Table 3 presents the results of the independent samples t-tests examining gender differences in the study variables.

Table 3

Gender Differences in Study Variables

Variable	Male (n = 203)		Female (n = 217)		T	p	Cohen's d
	M	SD	M	SD			
Chemistry Achievement	26.12	5.92	26.71	5.64	-1.06	.290	0.10
Academic Resilience	96.34	14.76	100.82	13.62	-3.26	.001	0.32
Academic Stress	57.83	11.09	56.62	10.63	1.15	.252	0.11
Adaptive ER Strategies	65.91	9.48	69.05	8.76	-3.50	.001	0.34
Maladaptive ER Strategies	52.06	11.73	50.75	11.21	1.17	.243	0.11

Note: N = 420, ER = Emotional Regulation

Significant gender differences were observed in academic resilience ($t(418) = -3.26$, $p = .001$, $d = 0.32$) and adaptive emotional regulation strategies ($t(418) = -3.50$, $p = .001$, $d = 0.34$), with female students scoring higher in both variables. No significant gender differences were found in chemistry achievement, academic stress, or maladaptive emotional regulation strategies.

DISCUSSION

This study examined the relationships between academic resilience, academic stress, emotional regulation, and chemistry achievement among secondary school students in Anambra State, Nigeria. The findings reveal important insights into the psychological factors that influence academic performance in chemistry.

Academic Resilience and Chemistry Achievement

Academic resilience emerged as the strongest predictor of chemistry achievement, accounting for a significant portion of the variance ($\beta = 0.42$, $p < .001$). This finding aligns with previous research demonstrating positive associations between academic resilience and academic performance (Fallon, 2010; Kwek et al., 2013; Alabi & Mustapha, 2015; Holdsworth et al., 2018). The robust relationship observed in this study (explaining approximately 18% of unique variance in chemistry achievement) exceeds the effect sizes reported in some previous studies of general academic resilience (Tudor & Spray, 2018; Anazodo et al., 2020), suggesting that resilience may be particularly important in chemistry education.

The strong predictive power of academic resilience in the context of chemistry education may be attributed to the challenging nature of the subject, which requires persistence and adaptability to master abstract concepts and solve complex problems. As Taasoobshirazi and Glynn (2009) noted, chemistry learning involves navigating multiple representation levels (macroscopic, sub-microscopic, and symbolic), requiring cognitive flexibility and perseverance when faced with conceptual difficulties. Similarly, Fatokun and Eniayeju (2017) observed that chemistry's multifaceted nature—combining theoretical concepts, mathematical applications, and laboratory skills—creates numerous potential obstacle points where resilience becomes critical for sustained engagement.

The positive relationship between academic resilience and chemistry achievement suggests that students who can effectively bounce back from academic setbacks, maintain focus despite distractions, and persevere through difficulties are more likely to succeed in chemistry. This aligns with Martin et al.'s (2017) findings that academic resilience facilitates deeper engagement with challenging academic content through increased effort, strategic resource allocation, and adaptive help-seeking behaviours. Similarly, Collie et al. (2017) found that resilient students demonstrate greater persistence when confronted with difficult tasks, leading to greater mastery of complex concepts.

In the Nigerian context specifically, this finding is consistent with Adeyemo's (2019) research showing that academic resilience significantly predicted science achievement among secondary school students, with resilient students demonstrating greater capacity to overcome the contextual challenges of Nigerian science education. Likewise, Olonade et al. (2021) found that resilience was particularly important for achievement in subjects perceived as difficult, including chemistry, physics, and mathematics.

This finding highlights the importance of fostering resilience in chemistry education, particularly in resource-constrained environments like many Nigerian schools, where students face numerous challenges including inadequate laboratory facilities, large class sizes, and limited instructional materials (Nbina & Viko, 2010; Emendu, 2018; Okafor & Okeke, 2021). As Chinawa et al. (2020) observed, Nigerian students must navigate significant obstacles to chemistry learning, including language barriers (as English is often a second language), insufficient practical experiences, and inconsistent power supply affecting laboratory work. Under these conditions, academic resilience becomes not merely advantageous but essential for achievement.

The connection between academic resilience and chemistry achievement also aligns with Bamidele et al.'s (2017) argument that psychological resources are particularly important in educational contexts where material resources are limited. Their research in Nigerian schools found that psychological factors, including resilience, explained a larger proportion of variance in science achievement in resource-poor versus resource-rich schools, suggesting that resilience may partially compensate for material deficiencies.

Furthermore, the predictive power of academic resilience observed in this study supports Morales' (2008) conceptualization of resilience as a "protective factor" that buffers against educational risk. In the Nigerian chemistry education context, these risks include negative subject stereotypes (Ezeudu & Obi, 2013), gender biases in science education (Olasehinde & Olatoye, 2014), and examination anxiety (Adeyemo, 2017), all of which may be mitigated through resilience processes.

Academic Stress and Chemistry Achievement

The negative relationship between academic stress and chemistry achievement ($\beta = -0.31$, $p < .001$) confirms findings from previous studies indicating that excessive stress impairs academic performance (Akgun & Ciarrochi, 2003; Yusoff et al., 2013; Pascoe et al., 2020). The magnitude of this relationship in our study (uniquely explaining approximately 10% of variance in chemistry achievement) is consistent with

Emotional Regulation and Chemistry Achievement

The findings regarding emotional regulation strategies provide valuable insights into the role of emotions in chemistry education. The positive relationship between adaptive emotional regulation

strategies and chemistry achievement suggests that students who can effectively manage their emotions through constructive approaches (e.g., positive reappraisal, problem-solving) are better positioned to succeed in chemistry. Conversely, the negative relationship between maladaptive strategies and achievement indicates that rumination, catastrophizing, and other counterproductive approaches to emotional management may hinder chemistry learning.

These findings align with research demonstrating the importance of emotional processes in academic functioning (Gumora & Arsenio, 2002; MacCann et al., 2020). They also extend previous work by highlighting the relevance of emotional regulation specifically in chemistry education, a domain traditionally associated with cognitive rather than affective factors.

The observed relationships between emotional regulation strategies and chemistry achievement may be understood through multiple mechanisms. First, effective emotional regulation may facilitate engagement with challenging material by preventing negative emotions from disrupting concentration and motivation. Second, adaptive emotional regulation may contribute to better laboratory performance by helping students manage frustration during complex or unsuccessful experiments. Third, constructive approaches to emotional management may enhance collaborative learning, which is increasingly emphasized in contemporary chemistry education.

Gender Differences

The finding that female students demonstrated higher academic resilience compared to their male counterparts' contrasts with some previous studies reporting no gender differences in resilience (Martin & Marsh, 2008) but aligns with others indicating female advantage (Khalaf, 2014). This gender difference may reflect socialization patterns in the Nigerian context, where girls often face greater educational barriers and may develop stronger resilience as a result.

Similarly, the observed female advantage in adaptive emotional regulation strategies is consistent with some previous research suggesting that females may be more skilled at certain aspects of emotional management (Nolen-Hoeksema, 2012). This finding could reflect gender-role socialization that encourages emotional awareness and expression among females.

Interestingly, despite female students' higher academic resilience and more adaptive emotional regulation, no significant gender differences were found in chemistry achievement. This finding contrasts with some previous studies reporting male advantage in chemistry performance in Nigerian schools (Ezeudu & Obi, 2013) but aligns with others indicating gender parity (Olasehinde & Olatoye, 2014). The absence of gender differences in achievement, despite differences in psychological factors, suggests that multiple variables influence chemistry performance, potentially offsetting each other in complex ways.

Implications

The findings support the theoretical frameworks underpinning this study. The significant relationship between academic resilience and chemistry achievement aligns with Martin and Marsh's (2006) 5-C model, suggesting that confidence, coordination, control, composure, and commitment indeed contribute to academic success in challenging subjects like chemistry. The negative impact of academic stress on chemistry achievement corroborates Lazarus and Folkman's (1984) transactional theory, indicating that perceived imbalances between academic demands and coping resources can undermine performance. This is particularly relevant in chemistry education, where conceptual challenges and laboratory demands may create significant stress for students. The differential relationships between adaptive versus maladaptive emotional regulation strategies and chemistry

achievement support Gross's (1998) process model, suggesting that the specific regulatory strategies students employ influence their academic functioning. The findings highlight the importance of considering emotional processes in science education, challenging traditional views that focus exclusively on cognitive factors.

The findings have several practical implications for chemistry education in Nigerian secondary schools. Chemistry teachers should incorporate resilience-building activities into their instruction, such as encouraging growth mindset, teaching error management, and providing constructive feedback. Schools could implement targeted programs to enhance students' capacity to overcome academic setbacks, particularly in challenging subjects like chemistry. Also, given the negative impact of academic stress on chemistry achievement, stress management techniques should be integrated into the curriculum. These might include time management training, relaxation exercises, and examination preparation strategies tailored to chemistry education.

Chemistry educators should recognize the importance of emotional processes in learning and provide guidance on adaptive emotional regulation strategies. This could involve teaching students to reframe negative experiences (e.g., unsuccessful experiments) as learning opportunities and to manage frustration during complex problem-solving tasks. Although no significant gender differences were found in chemistry achievement, the observed differences in psychological factors suggest that gender-responsive teaching approaches might be beneficial. Teachers could leverage female students' strengths in resilience and adaptive emotional regulation while providing additional support in these areas for male students.

Assessment practices in chemistry education should incorporate measures of psychological well-being alongside traditional content knowledge and skills. This holistic approach would provide a more comprehensive understanding of students' strengths and needs, facilitating targeted interventions.

Conclusion

This study investigated the relationships between academic resilience, academic stress, emotional regulation, and chemistry achievement among secondary school students in Anambra State, Nigeria. The findings revealed that academic resilience and adaptive emotional regulation strategies positively predicted chemistry achievement, while academic stress and maladaptive emotional regulation strategies negatively predicted achievement. Significant gender differences were observed in academic resilience and adaptive emotional regulation, with female students scoring higher in both variables.

The study contributes to the literature by highlighting the importance of psychological factors in chemistry education, challenging traditional approaches that focus primarily on cognitive variables. The findings suggest that interventions aimed at enhancing academic resilience, reducing academic stress, and promoting adaptive emotional regulation may improve chemistry achievement among secondary school students.

Limitations

Some limitations should be considered when interpreting the findings. While the study examined the independent contributions of psychological factors to chemistry achievement, it did not explore potential interaction effects. Future research should investigate how these variables might interact to influence performance, potentially through moderation or mediation analyses. This study focused on

senior secondary school students (SS2), and the findings may not generalize to other educational levels. Future research should examine these relationships across different age groups and educational stages.

Recommendations

Despite these limitations, this study makes a valuable contribution to understanding the complex interplay between psychological factors and academic achievement in chemistry education. By recognizing the importance of academic resilience, stress management, and emotional regulation in science learning, educators and policymakers can develop more effective approaches to supporting students' success in chemistry and other challenging academic domains.

Acknowledgments

The authors gratefully acknowledge the support provided by the Anambra State Post Primary Schools Service Commission in facilitating access to the schools that participated in this study. We also thank the school principals, chemistry teachers, and students who generously contributed their time and insights to this research.

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Cite as: Samuel, N. N. C. & Nnoli, J. N. (2025). Academic resilience, academic stress, and emotional regulation as predictors of secondary school students' achievement in chemistry in Anambra State. *Journal of Research in Industrial Technology and Educational Studies*, *1*(1), 105 - 121.